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Applications of IoT in Healthcare in India

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ABSTRACT

Internet of Things (IoT) is an emerging area that is attracting a lot of attention in various fields. One of the traditional areas in India that requires a lot of development and attention is healthcare. The shortage of qualified healthcare workers in rural areas has led to poor availability of these services in the rural areas which actually is a huge part of the country. This paper reviews various advancements in the area of IoT worldwide and how the same can be applied to healthcare in general. It surveys a lot of work that can contribute to application of IoT developments to the field of healthcare.

Keywords: IoT, WBANs, healthcare, Remote Monitoring, MAC Protocols, Security

I. INTRODUCTION

Healthcare in India has been in a relatively less developed state since independence. This is more so in case of rural India which shows a very dismal picture. Most of the healthcare facilities and personnel are concentrated in Urban areas where only 30% of the population resides.

As an example, the number of physicians in India per 1000 person population is only .699 as per 2012 WHO data. This is already a low number compared to the developed countries number of around 2-3 physicians per 1000 persons. The situation is much worse when one looks at rural India. According to National Health profile Report (NHP) 2013, only 33% of the Indian physicians work in Rural India where 70% of the population lives.

Here, based on the above report, 8% of the healthcare centres do not have qualified doctors or even medical staff. There are no lab technicians at 39% centres and 18% of the centres do not even have a medical pharmacist.

However, the current advancement in emerging technologies can be utilized by the country to bridge this gap between the rural and urban India. We will explore the developments in the area of Internet of Things (IOT) which can effectively address these problems.

Wireless and Internet connectivity has grown tremendously in India in the last two decades. As an example, the teledensity in the country (number of telephone connections per person) has grown from 10% in Urban India and .93% in Rural India in 2001 to 93.88% overall in July 2017. This includes a teledensity of 173% in Urban India and 57.45% in Rural India. This means that a phone connection (mostly wireless) is easily available even to rural households.

With this connectivity also came the internet which is easily accessible to most areas in the country. The connected network of various devices, appliances, vehicles, monitoring stations, along with their sensors, cameras, software and ainternet connectivity enables these devices to monitor, collect, share and exchange data is collectively known as Internet of Things. After the Internet, IoT is the expected next proliferation of networked devices that will revolutionize the way information is exchanged, not

only between the humans but between devices as well. These devices are expected to have the intelligence to take action based on the information received through IoT.

Cloud computing is the availability of network server remotely that can store and analyze data. All this is done on remote servers rather than storing the information on local computers. Cloud services are easily accessible and are making the computing infrastructure affordable as well as accessible.

IoT and Cloud technology can be combined together to provide effective remote healthcare. This involves monitoring of patients remotely through sensors and transmitting the data generated by sensors to central stations where qualified doctors and healthcare workers can analyse the data and take timely suitable actions to prevent medical emergencies.

Several projects have been undertaken in the area of remote healthcare. One of the popular work is project CodeBlue [1] at Harvard Sensor Network Lab where communication has been established between remote physicians and a patient's wearable sensor network. The other works include ALARM-NET [2], UbiMon [3], CareNet [4], SAPHIRE [5] and Lifeguard [6]

II. WEARABLE BODY SENSORS AND WEARABLE BODY AREA NETWORKS

The advances in remote monitoring of humans have been made possible through various wearable sensors that are used for monitoring the vital parameters of a body. The main signals which are normally monitored include the body temperature, blood pressure, Electrocardiogram (ECG), Electroencephalogram and Electromyogram, among others.

The data from these sensors is connected together through a platform known as Wide Area Body Network (WBAN). The WBAN consists of inputs from all the wireless sensors along with the database, data reliability and data transmission capability.

Most of the signals have low frequency, high data rates and latency of less than 250 millisecond. All these characteristics are taken into consideration while designing a WBAN.

Web based smart Applications have also been developed to display the data from WBANs.

WBAN design has to take into consideration several factors such as their energy efficiency, appropriate MAC protocols that cater to the traffic requirements of WBANs, Quality of Service supported by the network etc. Some of the technical challenges in designing the WBANs include frequency band selection, channel modelling, antenna design etc. A lot of these factors have been discussed in [7].

III. ENERGY EFFICIENCY OF WBANs

One very important aspect of WBANs is their energy efficiency. The sensors used in WBANs are required to be small, compact and they are required to be able to operate at low power levels. Often, these sensors operate on battery power to ensure mobility of patients and therefore it is even more important that they are energy efficient. Often sensors are implanted inside a patient's body where batteries can not be replaced for several years. In such cases energy efficiency is a very important criteria for WBAN design. A lot of energy is wasted during data communications between sensors and remote stations. This happens due to various inefficiencies such as collisions between transmissions etc. A power efficient WBAN has been developed where sleep and wakeup techniques have been used to conserve power. The same is reported in [8]

Researchers have also proposed an energy efficient collision free protocol for WBAN communications in [9] known as Cicada or Cascading Information

retrieval by Controlling Access with Distributed slot Assignment.

IV. MAC PROTOCOLS USED BY WBANs

The MAC protocols used by WBANs have their own specific requirements. The sensors that are used in WBANs have different characteristics. There are certain sensors that generate data at a faster rate and require more frequent polling and then there are sensors which don't require frequent access and may be polled sporadically. The traditional protocols like IEEE 802.15.1[10], 802.15.4[11] and 802.15.6[12][13] typically use CSMA/CA mechanism to access the medium. These protocols do not support priority of access which is required in case of WBANs. The CSMA/CA access protocols provide random access to all transmitters fairly which may not work well for WBANs environment. The work in [14] looks at the throughput, delay and performance of the CSMA/CA networks. The sensors that operate on a higher sampling rate may create more collisions while trying to transmit data as compared to the sensors with lower sampling rates.

TDMA based MAC protocols have also been considered for WBANs. The advantage of TDMA based MAC protocols is their high efficiency and low power requirements. The problems of excessive collisions is also handled very effectively in TDMA based protocols. [15] proposes an energy efficient TDMA based protocol BodyMAC which reduces the probability of collisions during transmissions.

V. QOS IN WBANS

WBANs use a variety of sensors that generate different types of traffic in the network. The traffic requirement of these sensors vary from one to another. The coordination between different sensors to be able to effectively communicate with the central monitors also proposes a challenge to the network designers.

Treatment of various traffic types based on their QoS has not been very effectively handled in 802.15.6 specifications. This usually requires special handling

The work presented in [16] has specifically presented a smart traffic approach that takes into consideration various QoS constraints and ensures that the critical traffic requirements are guaranteed.
Another research has proposed a special MAC protocol "RACOON" for supporting QoS requirements of multi user WBANs as opposed to standalone WBANs.

VI. SECURITY CONSIDERTIONS RELATED TO WBANs

Security is a major concern in any network which is accessible to outsiders. WBANs carry a lot of sensitive information about patients and therefore taking care of security aspects is very important and critical both from customer as well as ethical point of view.
The major issues related to security are :

- Confidentiality : A major concern of patients who are being remotely monitored is their privacy and the confidentiality of data. The patients are sceptical about their data being shared by people who do not need access to data. In some cases it is not even desirable. As an example, access to this data to the insurance company may lead to patient claims being rejected and therefore the patients may have objections to it.
- Integrity and Accuracy : Data integrity is a highly sensitive issue in healthcare. Any mix-up or error in data can lead to wrong diagnosis by healthcare experts leading to possible legal issues. Therefore it is essential that the WBAN design takes care of data integrity issues
- Availability : Continuity of communication between the WBANs and the monitoring centres is a very important aspect of the network which has to be taken care of while designing the

network. In case of critical patients, it is even more important that the network is available all the time and is not prone to reliability issues.

- Authentication : The data transmitted by the WBANs should be available only to the healthcare personnel who are authorized to see the data. It is very essential that the data can not be accessed by non authorized persons or sites. In order to ensure this, proper authentication procedures are essential.
- Accountability : In medical healthcare, it important that there is accountability for safe and secure handling of data. Any network provider has to ensure that the data is managed and handled securely and if there is failure on this front then there should be ways to hold the provider accountable.
- Data Freshness : Freshness implies that the data being sent by the WBANs is recent and is not an old replay by a hacker into the network
- Secure Localization: It is important in a lot of applications that the location of the patient can be correctly estimated. In absence of such a facility, an attacker may be able to send false data to the monitoring stations.
- There are multiple types of attack that can happen on an WBAN in absence of security mechanisms. These attacks may include change of data (integrity issue), misuse of data (confidentiality issue), impersonation, tracking, replaying etc. The work in [17] involves a lightweight authentication protocol that mutually authenticates the client and the server to ensure that the communication is secure against various types of attacks. Huang et al [18] have proposed a secure access mechanism for WBANs based on a hierarchical architecture.

VII. CONCLUSIONS

A lot of advancement has happened in the area of IoT and WBANs in the last decade. Several researchers have worked in the areas related to design, application and security aspects of IoT that impact the healthcare services.

This survey was inspired by the status of healthcare in India and the possibility that the advances in IoT can be applied for the advancement of better health for the country.

This paper has tried to present a review of lot of technology aspects and the work that has been done in the area. There is still a lot of work to be done in the areas related to energy efficiency, security, communications and various other aspects of WBANs. The healthcare vertical will immensely benefit from these advancements.

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